



PROFESSOR JOHN ROBISON.
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OUTLINES

OF

A COURSE

OF

Experimental Philosophy.

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U T L I N E S

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A C O U R S E

O F

Experimental Philosophy



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MDCCLXXIV

INTRODUCTION.

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ARTS—Sciences—Natural History—Philosophy.

Every change in the state of things is considered as an EFFECT, indicating the agency, characterising the kind, and measuring the degree of its CAUSE.

Necessary connexion—Physical Law—Phenomenology—Aitiology—Theory.

Appearances of Mind—Intellectual System—Supreme Mind—Natural Theology—Natural System.

Mechanical Philosophy—Chemistry—Physiology.

MECHANICAL PHILOSOPHY is the study of the sensible motions and actions of bodies, in order to discover the mechanical laws of nature, to explain subordinate phenomena, and to improve art.

PART I.

SECTION I.

Of Motion—Space—Time—Direction—Velocity, and its measure—Composition of motion—Acceleration, retardation, deflection, with their characteristics and measures.

A

SECT.

S E C T. II.

Of matter—Its distinguishing property—*Solidity*—does not arise from the contact of particles—Quantity of Matter—Density.

S E C T. III.

Of mechanical action—powers—forces—impulse—pressure—attraction—repulsion—tendency—reaction—resistance—

First law of motion. *Every body perseveres in a state of rest, or of uniform rectilineal motion, unless affected by some mechanical force.*

Second law of motion. *Every change of motion is proportional to, and has the direction of, the changing force.* Composition and resolution of forces—Equivalent or resulting force.

Accelerating, retarding, and deflecting forces—Central forces—centripetal—centrifugal—of systems—centre of position—motion of this centre, in consequence of external action, not affected by the mutual, equal, and opposite actions of the bodies which compose the system.

P A R T II.

MECHANICAL HISTORY OF NATURE.

S E C T. I. A R T. I.

Astronomy.

Phenomena of diurnal revolution—Fixed stars—planets
—Method of ascertaining their motions—Instruments and
observations in a fixed observatory—Instruments and ob-
servations for travellers.

Apparent motions of the sun and moon—year—month
—Calendar.

Apparent motions of the planets.

Detection of the real motions.

Solar system—Ptolemaic—Egyptian—Copernican—
Tychonic—Semitychonic—Decision which of these is a
just account of the celestial motions—Laws of Kepler.

1. The primary planets and comets describe round the
sun, and the secondary planets describe round their pri-
mary planets, areas proportional to the times.

2. The planets describe ellipses, having the sun or pri-
mary planet in one of the foci.

3. The squares of the periodic times are proportional
to the cubes of the mean distances.

PHYSICAL

PHYSICAL ASTRONOMY.

The planets are retained in their orbits round the sun by a force directed to the sun, and inversely proportional to the square of the distances from him. The secondary planets are retained in their orbits round their respective primary planets by forces directed to them, and varying according to the same law. They are also made to accompany their primary planets by a force directed to the sun, and varying according to the same law.

This force is mutual between the planets and the sun, and between the secondary planets and their primaries.

The planets are also actuated by forces directed to each other, and varying according to the same law.

The force by which the moon is retained in her orbit round the earth, is nowise different from the weight or gravity of common terrestrial matter. This is found to be directed, not to the centre of the earth, but to every part of it.

Hence it was justly inferred by the illustrious Sir Isaac Newton, that every particle of matter *gravitates* to every particle of matter, with a force inversely proportional to the square of the distance—Quantity of matter in the sun, and in some of the planets.

THEORY OF PHENOMENA—Elliptical motion of the planets—Disturbances of the planetary motions—Lunar irregularities—Figure of the earth—Tides—Trade winds on the earth and on Jupiter.



A R T. II.

Projectiles.

A heavy body, near the surface of the earth, falls with a motion which is uniformly accelerated. If projected directly upwards, it rises with a motion uniformly retarded. If projected in any other direction, it describes a parabola.—Theory of gunnery.

This motion is so much affected by the resistance of the air, that the theory is scarcely of any use for directing the practice.

S E C T. II.

It is highly probable that the particles of tangible matter are not in contact, but are connected by mechanical forces, which, like gravity, act at a distance.

Theory of Father Bosovich—Limit of cohesion—of dissolution—solidity—elasticity—softness—want of elasticity—fluidity of liquids—of vapours.

Propagation of forces through the parts of solid bodies, —strength and strain of materials.

A R T.

A R T. I.

MECHANISM OF SOLID BODIES.

I. Production of motion in free space—when the direction of the force passes through the centre of position—when it does not pass through the centre—combination of progressive and rotatory motion—spontaneous axis of conversion—nutation of the earth's axis—precession of the equinoxes.—Rotation of the planets—whirling of shot.

II. Change of motion by immoveable obstacles—penetration—of clay—of sand—reflection—of cannon shot from such bodies.

III. Change of motion by impulse—Laws of collision of unelastic bodies—of elastic bodies—Communication and extinction of motion—Dispute about the force of moving bodies—Conservatio virium vivarum.

IV. Change of motion by constrained paths—motion round fixed points or axes—centre of percussion.

V. Solidity combined with gravity—centre of gravity—stability—sliding—rolling—attitudes of animals—construction of arches and domes—and roofs.

VI. Of pendulums—motion in a cycloid—as the circumference of a circle is to its diameter, so is the time of one vibration of a cycloidal pendulum to the time of falling through half its length—measure of the accelerative power of gravity—variation of gravity in different parts of the earth—regulation of clocks—centre of oscillation.

A R T.

A R T. II.

THEORY OF MACHINES.

Imperfect state of this theory—false maxim adopted—leading questions—1st, What is the proportion of the pressures excited in the different parts of the machine—2d, What will be the motion of a machine, urged by a given force, and overcoming a given resistance.

Question 1st, Mechanical powers—Lever—pulley—inclined plane—wedge—compound machines—mechanism of animal bodies.

Question 2d, Impelled point—working point—momentum of impulse—momentum of effect—causes which prevent the continual acceleration of machines—changes produced in the pressure of the impelling power and resistance by the motion of the impelled and working points—important propositions.

Proposition 1st, When a machine has acquired an uniform motion, the momenta of impulse and of effect are equal.

Let f be the pressure which the impelling force exerts on the machine at rest. Let p be the pressure which it exerts on the impelled point moving with the velocity m . Let c be that velocity of the impelled point which annihilates the pressure of the impelling force. Let v be made equal to $c - m$, so as to express what may be termed the relative velocity. Let it be discovered by experiment, that
the

the pressure exerted by the impelling force, varies in the proportion of v^q .

Proposition 2d, The performance of a machine is the greatest when $m = \frac{c}{q + 1}$

Maxims for the Construction of Machines.

A R T. III.

OF THE MECHANISM OF FLUIDS.

A fluid body is such whose parts yield to the smallest impression, and, by yielding, are easily moved among themselves.

Imperfect fluidity—viscosity—fluidity the effect of fire—mistakes about the formal cause of fluidity.

All fluids compressible—Florentine experiments—Canton's more simple experiments—division of the subject—hydrostatics—pneumatics.

HYDROSTATICS.

Prop. 1st, If a fluid without weight be contained in any vessel having two orifices, to which are applied two external forces, an equilibrium will obtain, if the forces are in the proportion of the orifices to which they are applied.

Prop.

Prop. 2d, The pressure on the horizontal bottom of a vessel filled with a heavy fluid, of which the upper surface is horizontal, is equal to the weight of a column of that fluid, having the bottom for its base, and the depth of the bottom under the surface of the fluid for its height. This pressure is independent of the figure of the vessel, and of the quantity of fluid which it contains.

Prop. 3d, Any surface immersed in a heavy fluid, of which the upper surface is horizontal, is perpendicularly pressed with a force equal to the weight of a column of that fluid, having the surface pressed for its base, and the depth of its centre under the surface of the fluid for its height.

Prop. 4th, The *vertical* pressure on any surface immersed in a heavy fluid, having a horizontal surface, is equal to the weight of the *vertical* column which may be incumbent on that surface.

Cor. 1st, The force requisite for supporting a vessel containing a heavy fluid is equal to the weight of the vessel and fluid.

Cor. 2d, The horizontal pressures on the opposite sides of the vessel are equal and opposite.

Prop. 5th, The upper surface of a homogeneous heavy fluid in any vessel, or system of communicating vessels, is horizontal.

Conducting of water—Levelling—

Prop. 6th, If different heavy fluids, which do not mix, are contained in a vessel, their separating surfaces are horizontal, and the heaviest will occupy the lower place.

Practical inferences—Pressure of water on a square foot is $62\frac{1}{2}$ lbs. for every foot in height—strength of dams—banks—dock gates—pipes.

B

Prop.

Prop. 7th, A solid immersed in a heavy fluid, is pressed upward with a force equal to the weight of the fluid which it displaces.

Mechanism of floating bodies—Burthen and stability of ships.

Investigation of the density of bodies—Specific gravity—Hydrostatic balance—Hydrometer for spirits—Bubbles for spirits—Problem of Archimedes—Cautions—Change of specific gravity by chemical mixture.

HYDRAULICS.

Treats of the motion and impulse of fluids.—The theory of these motions is very imperfect. It is usually received as a fundamental proposition, that

A fluid impelled by its weight alone, issues from any orifice with the velocity which a heavy body would acquire by falling from the surface of the fluid to the orifice.

Many circumstances, of which the effect is not understood, cause the velocity to differ greatly from that now assumed.

Of the motion of fluids impelled by pistons—circumstances of great consequence in the construction of machines for this purpose.

Of the impulse and resistance of fluids—very imperfectly known.

Of hydraulic machines—Overshot wheels—Undershot wheels—Parent's mill—Motion and working of ships.

PNEUMATICS.



PNEUMATICS.

Air—proofs of its materiality—of its weight—specific gravity—pressure arising from the weight of air—it is equal to near 15 lbs. on a square inch—rise of water in pumps and syphons—Toricellian experiment—Barometer—method of determining the height of mountains.

Compressibility of air—Condensing syringe—Exhausting syringe—Air pumps—Smeaton's.—The elasticity of air is nearly proportional to its density—Sea gage—Height of the atmosphere—Correct method for determining the height of mountains by the barometer—Connection between the height of the Mercury in the barometer and the state of the weather.

Explanation of natural phenomena—Suction—Animal breathing—Air bladder of fishes—Drawing of chimneys—Causes of smoking vents—Cures—Reciprocating springs.

Pneumatic machines—Bellows—Water blast—Wind gun—Diving bell—Pumps—Sucking pumps—Forcing pumps—Air barrel—Important maxims—Hungarian machine.

Undulation of air—Sound—Production of Sound—Musical sound and pitch—Musical instruments—Theory of music.

Boiling of fluids—Steam engine—Savary's—Newcomen's—Watt's.

Action of inflamed gunpowder—Theory of fire arms and artillery.

S E C T.

S E C T. III.

MAGNETISM.

Leading facts. 1st, Any oblong piece of iron, at liberty to move, will arrange itself in a certain determinate position with respect to the axis of the earth.

2. Any such piece of iron attracts, and is attracted by, another similar piece.

Difference between common iron and magnets or loadstones. The magnetism of the latter is determinate and permanent; that of the former is indifferent and transitory.

Leading facts in magnets or loadstones. 1st, A magnet arranges itself in a determinate position—poles.

2d, The dissimilar poles of two magnets attract each other, and their similar poles repel each other.

Law of magnetic attraction and repulsion—It may be expressed by the ordinates of an asymptotic curve, every where convex towards its abscissa.

Variation of the compass—Changes of this variation—dip of the mariners needle.

Theory of the mutual action of magnets—Magnets, placed with their dissimilar poles fronting each other, are mutually attracted—if their similar poles front each other, they are mutually repelled, except at very small distances
in

in some cases—This action is increased, by increasing the force of one or both—by diminishing the distance between them—and by increasing the length of one or both.

A magnet B, in the neighbourhood of another magnet A, arranges itself in a determinate position—polarity of B—directive power of A—these are increased by increasing the power of either—by diminishing their distance—by increasing the length of A—by diminishing the length of B—A magnet may exert a great directive power on another magnet, while its attractive power may be insensible.

The magnetism of magnets is, in some degree, transitory—soonest acquired and lost by soft steel—most slowly by hard steel and loadstones—Various ways in which it is acquired and lost—most remarkably by vicinity to magnets.

Theory of the mutual action of magnets and iron—Any piece of iron becomes a magnet by simple juxtaposition to a magnet, and its poles have a determinate position with respect to the poles of the magnet employed—Magnetism by induction—This is the reason why a piece of iron is always, and in every situation, attracted by a magnet—It is also the cause of that curious arrangement of iron-filings strewed round a magnet, which has given rise to the usually received, but false theories of magnetism.

Directions for making artificial magnets—Antheaume's method—Method of Mitchell and Canton.

Dr Gilbert's theory of magnetism—The earth is a great magnet—The action of this magnet is the cause of all the phaenomena of magnetism, both natural and artificial—

This

This theory abundantly confirmed by experiment—Explanation of the change of the position of the mariner's needle.

Hypothesis of Æpinus.

Magnetical fluid—its particles repel each other, but attract the particles of some ingredient in iron, with a force decreasing with an increase of distance—The particles of this ingredient in iron repel each other in the same manner—The magnetical fluid is moveable—with great difficulty in the pores of hard steel and loadstones—more easily in the pores of soft steel and iron—Overcharged pole—Undercharged pole—Neutral point—This hypothesis very agreeable to all the phaenomena.

S E C T. IV.

ELECTRICITY.

A body is said to be electrical or electrified when it attracts, and, after contact, repels another body—Various sources of this quality—friction—change of temperature—change of state in fusion, congelation, evaporation, condensation, solution, precipitation, animal and vegetable powers—*Electricity by excitation—Excited electricity—Electrics—Non electrics.*

Any body B, brought into the neighbourhood of an electrical body A, becomes electrical—*Induced electricity—Electricity by position*—In this manner the operation of the cause of electrical phaenomena may be said to be propagated

gated through bodies—*Conductors*—*Non conductors*—a body rendered electrical by position is always attracted—perfect similarity between the phaenomena of induced magnetism and induced electricity.

If B be brought very near to A, a spark is observed between them, B becomes permanently electrical, and the electricity of A is diminished—*imparted*, or *communicated electricity*—A body rendered electrical by communication is always repelled—*Electrometer*—In order that a body may exhibit appearances of electricity, it must be surrounded by non conductors—*insulation*.

Electrical machine—Electric—Rubber—prime conductor.

Hypothesis of Dr Franklin, improved by Æpinus

Similar to his magnetical hypothesis—Electrical fluid—proofs of its existence—law of action similar to the law of the magnetical fluid—Action inversely as the square of the distance.

Application of this Hypothesis.

Undercharged body—Overcharged body—undercharged part—overcharged part—State of neutrality—*Excitation by friction*—When two bodies are rubbed together, one of them becomes overcharged, and the other becomes undercharged—*Plus*—*Minus*—*Positive electricity*—*Negative electricity*—Circumstances which promote the emission or absorption—*Electroscope*—Maxims for constructing electrical machines.

Theory of induced electricity—Theory of the electrophorus.

Theory of communicated electricity—Distribution of the electrical fluid—Redundant fluid and redundant matter

ter more nearly proportioned to the surface than to the quantity of matter—Tendency to escape from points and edges—Cause of the observed stream of electrified air—Pencil of light—Star—Electrical spark and snap—Vivacity depends on the quantity of fluid transferred—Method of producing a great accumulation by induction—Theory of coated glass, or of the Leyden phial—the accumulation is chiefly in the glass itself—Electrical shock.

Miscellaneous experiments, exhibiting the most remarkable effects of the electrical fluid—Medical electricity.

Theory of thunder and lightning—protection from its dangerous effects—Of earthquakes—Aurora Borealis.

S E C T. V.

OPTICS.

Medium of vision—why thought necessary—proofs of its existence—phosphori—light of diamonds—effects of illumination on plants and minerals—LIGHT—materiality of—its mechanical nature to be inferred from the phenomena.

L A W I.

Light, or the cause of vision, moves uniformly in straight lines, at the rate of about 200,000 miles in a second—Aberration of the heavenly bodies.

Radiant

Radiant point—Beam of light—Ray—Pencil—Convergent—Divergent—Focus, real and virtual—Image, real and virtual.

Intensity of light in a beam and pencil—Brightness—Interception of light.

Illumination—shadow—penumbra—Camera obscura of Battista Porta—Visibility of bodies—Shining bodies—Illuminated bodies—Reflection of light—Reflecting plane—plane of reflection—Angle of incidence and of reflection.

L A W II.

The angles of incidence and reflection are equal

CATOPTICS—Theory of mirrors—plane—spherical—cylindrical, &c.—Aberration.

Transparent bodies are called Media—When light passes obliquely through the surface which separates two media, its direction is changed, and the light is said to be *refracted*.

L A W III.

The sine of the angle of incidence is to the sine of the angle of refraction in a constant ratio.

DIOPTRICS—Refractive power different in different bodies—Refraction through several media—through the atmosphere—Reflection from the posterior surface of transparent bodies—Brilliancy of jewels—of dew drops—Theory of refraction through plane and spherical surfaces—through glasses—lense—convex—concave—plano-convex, and concave—double convex, and concave—Meniscus.

C

Of

Of the eye—description of the eye—progress of light through the eye—formation of the picture at the bottom—connection of this with vision—seat of vision—defects of vision, and remedies—Curious and important facts.

Of the ideas acquired by sight—direction of objects—relative situation—objects are seen erect by means of inverted pictures—magnitude of objects—figure—distance—Errors of judgment in these circumstances—Perspective, lineal, and aerial—horizontal moon—Brightness of objects—single vision—double vision—squinting.

Vision by means of mirrors and glasses—Apparent magnitude and distance—Field of vision—brightness.

Optical instruments. First class: Camera obscura—Magic lanthorn—Solar microscope—Helioscope—Burning mirrors and lenses.—Second class: Microscopes—simple—compound—Telescopes—Galilean—astronomical—day telescope—Dollond's eye-piece—Reflecting telescope—Newtonian—Gregorian—General defects of optical instruments.

Of colour—*The perception of colour is the effect of a property inherent in the rays of light, by which each kind is fitted for invariably exciting the sensation of a particular colour—*This quality not produced or changed by any reflexion or refraction—Homogeneous light—Heterogeneous light—The perception of whiteness is the effect of the combined action of all the heterogeneous rays, illuminating the same surface, or falling on the same part of the eye—Whiteness of snow, froth, paper, pounded glass, &c.——Primitive colours—All others arise from a mixture of these—The colours of natural bodies arise from their quality

lity of reflecting or transmitting more copiously the rays which excite the sensations of those colours.

L A W IV.

The rays of different colours have different degrees of refrangibility, in the following order, red, orange, yellow, green, blue, purple, violet; the violet rays being most refracted—*Dispersion of light*—Bodies differ in their dispersive, as well as in their refractive powers.

L A W V.

Those rays which are most refrangible, are also most reflexible from the posterior surface of transparent bodies.

L A W VI.

If a transparent plate has less than a certain determinate thickness, no light is reflected, the whole passing through. This thickness is different in different substances, for differently coloured rays, and for different angles of incidence.

L A W VII.

When homogeneous light falls on a transparent plate, of which the thickness is 1, 3, 5, 7, &c. it is reflected;—but, if the thickness be 2, 4, 6, 8, &c. it is transmitted.

Explanation of the coloured rings observed on the top of a soap bubble, or between the object glasses of long telescopes.

lescopes.—The rays of light are alternately in situations which are favourable to reflection or to transmission.—These fits of easy reflection and transmission, recur at equal intervals of space and time.

L A W VIII.

When light passes by any body, at certain very small distances, it is alternately inflected and deflected—Light is acted on by bodies at a distance.

Explanation of the rainbow, halo, and parhelion.

Explanation of the colours of natural bodies—those transparent bodies reflect light most copiously which have the greatest refracting power—The small parts of almost all bodies are transparent—Opacity arises from the interperision of transparent particles having different refracting powers—the colours of bodies arise from the thickness of their transparent particles—these thicknesses may be discovered by means of the colour.—Light is not reflected by impact on the solid matter of bodies.

Application of these doctrines to the improvement of optical instruments—Great defect of refracting instruments—Achromatic telescopes.

Inferences from the optical laws, tending to explain the mechanical nature of light.

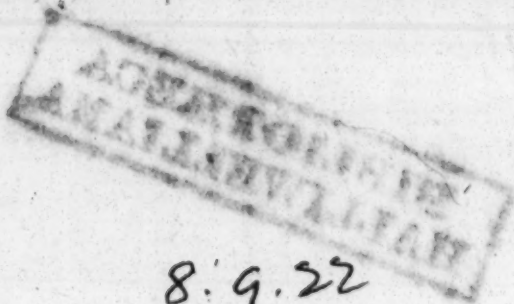
The most obvious and most general opinion is, that light is a stream of matter, emitted from the shining body—many difficulties attend this opinion—Theory of Descartes—Huyghens imagines that light is an elastic fluid, and that the optical phenomena are the effects of the undula-

tion

tion of this fluid, as found is the effect of the undulations of air—Waller supposes that the optical phenomena are the effects of the undulation of aether—His explanation of the motion of light—cosmic differences of undulations—reflection—visibility of objects—refraction. This theory is hypothetical, and the application of the hypothesis is incompatible with the established principles of mechanical philosophy.

Arguments which support the common opinion concerning the nature of light—proofs of its materiality—chemical effects—it seems to be the source of the green faecula, and of the aromatic oils of plants—it is imbibed and emitted by many bodies—phosphori—diamonds—spars.

The common opinion explains, in perfect consistency with mechanical laws, all the phenomena of illumination, reflection, refraction, and inflection—removal of the chief difficulties which attend this opinion—Mr Wilson's experiment for deciding the question—Conclusion.



J. Halliwell
Jun 1870

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